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In re Application of:

TADAYOSHI TOMINAGA et al

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MAIL STOP AFTER FINAL

For: SURFACE TREATING METHODS OF TITANIUM PARTS

DECLARATION UNDER 37 CFR 1.132

We Tadayoshi Tominaga, Naoki Komoto and Teruhisa Ushio do hereby declare as follows:

We are the named inventors of the above-identified patent application.

An error was made in the preparation of the specification of the above-identified patent application in that the proper units were omitted in the disclosure of surface roughness Rz.

Rz is defined in the attached Japanese Industrial Standard JIS B 0601 a copy of which is attached hereto. According to the Standard, a section of standard length is sampled from the mean line on the roughness chart. The distance between the peaks and valleys of the sampled line is measured in the y direction and the average peak is obtained among the five tallest peaks and the

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average valley is obtained between the five lowest valleys. The sum of these two values is expressed in micrometers.

Thus, it is known to those of ordinary skill in the art that the proper unit of measurement of the parameter Rz is micrometers.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, or any patent issued thereon.

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JIS B 0601
(1994)

Surface roughness -

Definitions and designation

1. **Scope** This Japanese Industrial Standard specifies the definitions and designation of the arithmetical mean roughness, maximum height, ten-point mean roughness, mean spacing of profile irregularities, mean spacing of local peaks of the profile and profile bearing length ratio, which are the parameters expressing the surface roughness of industrial products.

Remarks: The International standards corresponding to this Standard are shown below:

ISO 468-1982 Surface roughness — Parameters, their values and general rules for specifying requirements

ISO 3274-1975 Instruments for the measurement of surface roughness by the profile method — Contact (stylus) instruments of consecutive profile transformation — Contact profile meters, system M

ISO 4287/1-1984 Surface roughness — Terminology Part 1: Surface and its parameters

ISO 4287/2-1984 Surface roughness — Terminology Part 2: Measurement of surface roughness parameters

ISO 4288-1985 Rules and procedures for the measurement of surface roughness using stylus instruments

2. **Definitions and symbols** For the main terms used in this Standard, the following definitions apply.

The symbols for them are given in parentheses following each term.

(1) **surface roughness** Each arithmetical mean value of arithmetical mean roughness (R_a), maximum height (R_y), ten-point mean roughness (R_z), mean spacing of profile irregularities (S_m), mean spacing of local peaks of the profile (S) and profile bearing length ratio (t_p) which are the parameters expressing the surface roughness at each part sampled randomly from the surface of an object (hereafter referred to as "objective surface").

Remarks 1. Generally in an objective surface, surface roughness on individual positions is not uniform, and usually presents considerably large dispersion. Therefore, in assessing the surface roughness of the objective surface, it is necessary to determine the measuring positions and numbers thereof so that the population mean can be assumed effectively.

2. According to the objects of measurement, an assessed value at one point on the objective surface may represent the surface roughness of the entire surface.

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Informative reference 2 Attached Fig. 3.

Position of the cone angle tolerance AT with the same sign symbol for AT_i and AT_e on one side with regard to the basic cone angle α
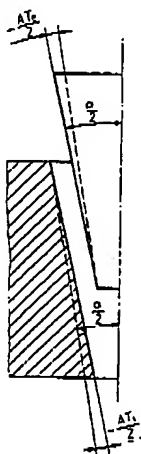
From the indication on drawing:

(a) When internal cone $\alpha'{}^{AT_i}_0$
  external cone $\alpha'{}^{AT_e}_0$

  it results in contact at the larger or smaller cone diameter or the whole conical surface depending on the actual cone angle.

(b) When internal cone $\alpha{}^0_{AT_i}$
  external cone $\alpha{}^0_{AT_e}$

  it results in contact at the larger or smaller cone diameter or the whole conical surface depending on the actual cone angle.
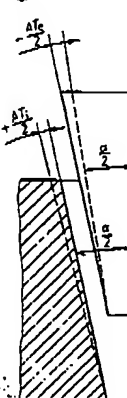
Informative reference 2 Attached Fig. 4.

Position of the cone angle tolerance AT with opposite sign symbol for AT_i and AT_e on one side with regard to the basic cone angle α
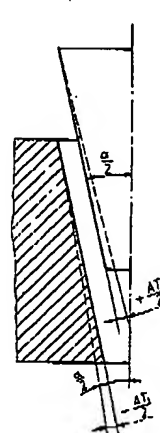
From the indication on drawing:

(a) When internal cone $\alpha'{}^{AT_i}_0$
  external cone $\alpha{}^0_{AT_e}$

  it results in contact at the smaller cone diameter or at the whole conical surface depending on the actual cone angle.

(b) When internal cone $\alpha{}^0_{AT_i}$
  external cone $\alpha'{}^{AT_e}_0$

  it results in contact at the larger cone diameter or the whole conical surface depending on the actual cone angle.

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(2) profile curve   A contour appears on a cut end, when a surface to be measured has been cut with a plane which is perpendicular to that surface.

Remarks: In this cutting, if the surface has generally the directionality, it shall be cut in perpendicular in that direction.

(3) roughness curve   A curve which has been cut off any longer surface waviness component than a prescribed wavelength from the profile curve by means of phase compensation type high-pass filter.

(4) cut-off value of roughness curve (λ_c)   A wavelength corresponding to the frequency which makes the gain of phase compensation type high-pass filter 50 % (hereafter referred to as "cut-off value").

(5) reference length of roughness curve (l)   A length of a part made by sampling the length of cut-off value from the roughness curve (hereafter referred to as "reference length").

(6) evaluation length of roughness curve (l_n)   A length including one or more reference length used for evaluation of surface roughness (hereafter referred to as "evaluation length"). The standard value of evaluation length shall be five times the reference length.

(7) waviness of filtered wave   A curve made by cutting off the component of surface roughness shorter than a given wavelength from the profile curve by means of phase compensation type low-pass filter (see Fig. 1 (a)).

(8) mean line of roughness curve (m)   A line made by converting the waviness of filtered wave at the part sampled from the profile curve to the straight line (hereafter referred to as "mean line") (see Fig. 1 (a)).

(9) profile peak   An outwardly directed entity of profile surrounded by the roughness curve and the mean line connecting two adjacent points of the intersection made when cutting the roughness curve with the mean line (see Fig. 1 (b)).

Remarks: In the roughness curve, the outwardly directed portion from the mean line at the beginning and the end of the reference length should be considered as a profile peak.
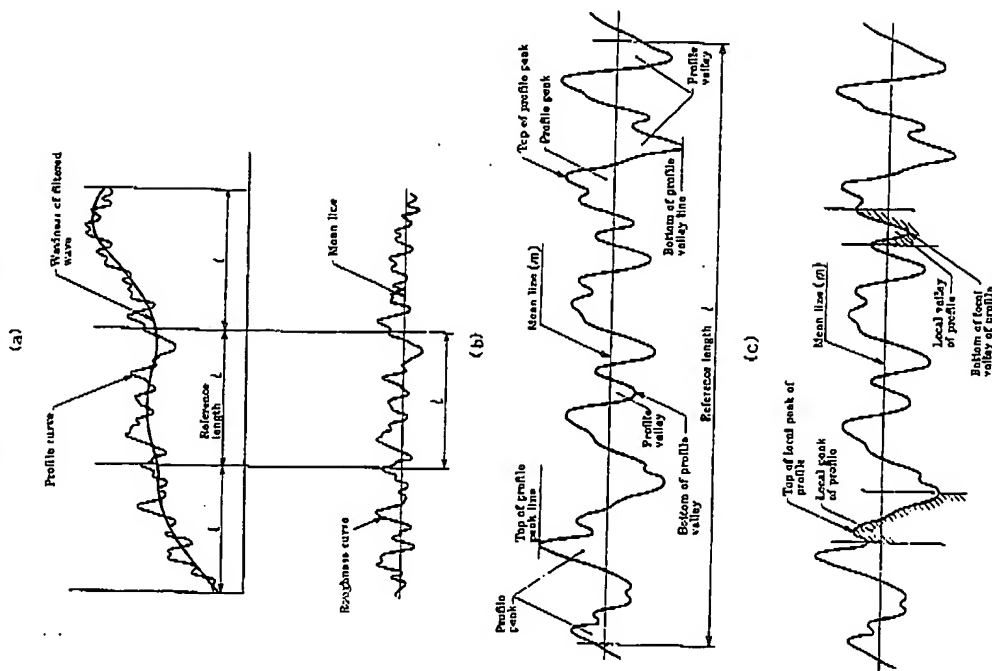
(10) profile valley   An inwardly directed portion of space surrounded by the roughness curve and the mean line connecting two adjacent points of intersection made when cutting the roughness curve with the mean line (see Fig. 1 (b)).

Remarks: In the roughness curve, the inwardly directed portion from the mean line at the beginning and end of the reference length should be considered as a valley.

(11) top of profile peak   A point of the highest altitude in the profile peak of roughness curve (see Fig. 1 (b)).

(12) bottom of profile valley   A point of the lowest altitude in the profile valley of roughness curve (see Fig. 1 (b)).

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(13) top of profile peak line   Of the reference lengths sampled from the roughness curve, the line parallel to the mean line passing through the highest top of profile peak (see Fig. 1 (b)).

(14) bottom of profile valley line   Of the reference lengths sampled from the roughness curve, the line parallel to the mean line passing through the lowest bottom of profile valley (see Fig. 1 (b)).

(15) cutting level   A vertical distance between the top of profile peak line and the line parallel to the top of profile peak line intersecting the roughness curve.

(16) local peak of profile   A part of entity between two adjacent minima of the roughness curve (see Fig. 1 (c)).

(17) local valley of profile   A part of space between two adjacent maxima of the roughness curve (see Fig. 1 (c)).

(18) top of local peak of profile   A point of the highest altitude in the local peak of profile (see Fig. 1 (c)).

(19) bottom of local valley of profile   A point of the lowest altitude in the local valley of profile (see Fig. 1 (c)).

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3. Definition and designation of arithmetical mean roughness (R_a)

3.1 Definition of R_a

3.1.1 Determination of R_a. R_a means the value obtained by the following formula and expressed in micrometer (µm) when sampling only the reference length from the roughness curve in the direction of mean line, taking X-axis in the direction of mean line and Y-axis in the direction of longitudinal magnification of this sampled part and the roughness curve is expressed by $y = f(x)$:

$$R_a = \frac{1}{l} \int_0^l |f(x)| dx$$

where, l : reference length

Fig. 2. Determination of R_a
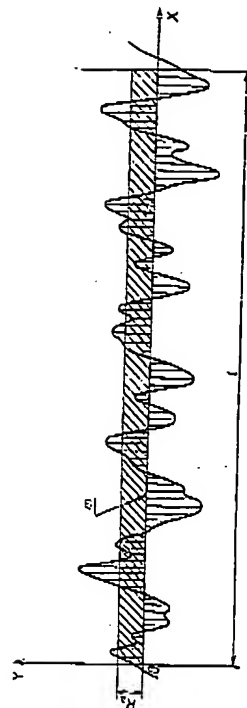
3.1.2 Cut-off values   The cut-off values when obtaining R_a shall generally be chosen from the following six kinds:

0.08,   0.25,   0.8,   2.5,   8,   25   Unit: mm

3.1.3 Standard values of cut-off values   The standard values of the cut-off value and the evaluation length corresponding to the range of R_a, when obtaining R_a, shall be in accordance with the divisions in Table 1.

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Fig. 1. Explanation on profile curve, roughness curve, mean line, reference length, profile peak, profile valley, local peak of profile and local valley of profile

(a)

(b)

(c)

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Table 1. Standard values of cut-off value and evaluation length in determining R_a

Range of R_a (μm)		Cut-off value λ_c (mm)	Evaluation length l_n (mm)
Exceeding	Max.		
(0.006)	0.02	0.08	0.4
0.02	0.1	0.25	1.25
0.1	2.0	0.8	4
2.0	10.0	2.5	12.5
10.0	80.0	8	40

The value within ( ) is given for informative reference.

Remarks: R_a shall be determined by firstly designating the cut-off values. In carrying out the designation or instruction of the surface roughness, as it is inconvenient to designate that on all such occasions, values given in Table 1 should be used generally.

3.2 Expression of R_a

3.2.1 Designation of R_a The designation of R_a shall be as follows:

Arithmetical mean roughness ____ μm, Cut-off value ____ mm, Evaluation length ____ mm

or

____ μmR$_a$, λ_c ____ mm, l_n ____ mm

Remarks 1. In the case where the value of R_a obtained by using the standard value of the cut-off value given in Table 1 is in the range shown in Table 1, the designation of the cut-off value may be omitted.

2. In the case where the evaluation length is five times the cut-off value that is the standard value of evaluation length in Table 1 is used, the designation of the evaluation length may be omitted.

3.2.2 Preferred number series of R_a When the surface roughness is designated by R_a, the preferred number series of Table 2 should be used generally.

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Table 2. Preferred number series of Ra
Unit: μm

0.008				
0.010				
0.012	0.125	1.25	12.5	125
0.016	0.160	1.60	16.0	160
0.020	0.20	2.0	20	200
0.025	0.25	2.5	25	250
0.032	0.32	3.2	32	320
0.040	0.40	4.0	40	400
0.050	0.50	5.0	50	
0.063	0.63	6.3	63	
0.080	0.80	8.0	80	
0.100	1.00	10.0	100	

Remarks: It is preferable to use the preferred number series of common ratio of 2 shown with thick figures.

3.2.3 Sectional designation of R_a If it is required to designate R_a in a certain section, numerical values corresponding to the upper limit (that of the larger designation value) and lower limit (that of the smaller designation value) shall be stated additionally by selecting from Table 2.

Example 1. In the case where standard values of cut-off values for upper limit and lower limit are equal A sectional designation when the upper limit of 6.3 μmR$_a$ and the lower limit of 3.2 μmR$_a$ shall be designated as (6.3 to 3.2) μmR$_a$. In this case, 2.5 mm shall be used for the cut-off value.

Example 2. In the case where standard values of cut-off values for upper limit and lower limit are different A sectional designation when the upper limit of 12.5 μmR$_a$ and the lower limit of 3.2 μmR$_a$ shall be designated as (12.5 to 3.2) μmR$_a$. In this case, it means that the value of R_a measured by a cut-off value of 8 mm is 12.5 μmR$_a$ or under, and that the value of R_a measured by a cut-off value of 2.5 mm is 3.2 μmR$_a$ or over.

Remarks 1. In the case where it is required to equalize the cut-off values corresponding to the upper and lower limits, or in the case where cut-off values other than standard values of Table 1 are to be used, the cut-off values shall be appended. In Example 2, when the cut-off value corresponding to the upper and lower limits is taken as 8 mm, it shall be designated as (12.5 to 3.2) μmR$_a$, λ_c 8 mm.

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2. R_a of the upper and lower limits mentioned here shall be the arithmetical mean values of R_a at several points sampled randomly from the designated surface, but shall not be the maximum value of individual R_a.

4. Definition and designation of maximum height (R_y)

4.1 Definition of R_y

4.1.1 Determination of R_y R_y shall be that only the reference length is sampled from the roughness curve in the direction of mean line, between the top of profile peak line and the bottom of profile valley line on this sampled portion is measured in the longitudinal magnification direction of roughness curve and the obtained value is expressed in micrometer (μm) (see Fig. 3).

Fig. 3. Determination of R_y

$$R_y = R_p + R_v$$
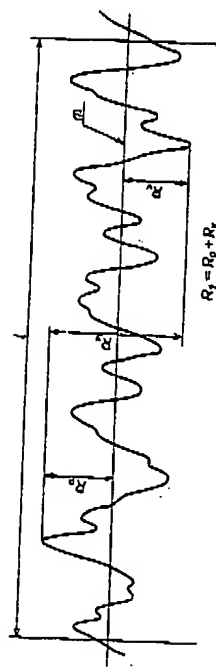
Remarks: In the determination of the maximum height (R_y), a length corresponding to the reference length shall be sampled from the part which is free from extraordinary high peak and deep valley considered as flaws.

4.1.2 Reference length In the determination of R_y, reference lengths shall generally be chosen from the following six kinds:

0.08, 0.25, 0.8, 2.5, 8, 25. Unit: mm

4.1.3 Standard values for reference lengths The standard values for reference lengths and evaluation lengths corresponding to the range of R_y, when determining R_y, should conform to the division of Table 3 generally.

Table 3. Standard values for reference lengths and evaluation lengths in determination of R_y

Range of R_y (μm)		Reference length l (mm)	Evaluation length l_n (mm)
Exceeding	Max.		
(0.026)	0.10	0.08	0.4
0.10	0.50	0.25	1.25
0.50	10.0	0.8	4
10.0	50.0	2.5	12.5
50.0	200.0	8	40

The value within ( ) is given for informative reference.

Remarks: R_y shall be determined upon designation of the reference length at first, however, in indicating and designating the surface roughness, because it is inconvenient to designate the reference length on all such occasions, values given in Table 3 should be used generally.

4.2 Expression of R_y

4.2.1 Designation of R_y R_y shall be designated as follows:

Maximum height _____ μm, Reference length _____ mm, Evaluation length _____ mm

or

_____ μmR_y, l _____ mm, l_n _____ mm

Remarks 1. In the case where the maximum-height value which has been obtained using the standard value of the reference length given in Table 3 lies within the range given in Table 3, the designation of the reference length may be omitted.

2. In the case where the evaluation length uses five times the reference length, namely the standard value of evaluation length shown in Table 3, the designation of evaluation length may be omitted.

4.2.2 Preferred number series of R_y In designating the surface roughness by R_y, the preferred number series of Table 4 should be used generally.

5.1 R_z の定義

Table 4. Preferred number series of R_z

Unit: μm

0.025	0.125	1.25	12.5	125	1250
0.032	0.160	1.60	16.0	160	1600
0.040	0.20	2.0	20	200	
0.050	0.25	2.5	25	250	
0.063	0.32	3.2	32	320	
0.080	0.40	4.0	40	400	
0.100	0.50	5.0	50	500	
	0.63	6.3	63	630	
	0.80	8.0	80	800	
	1.00	10.0	100	1000	

Remarks: It is recommended to use the number series of common ratio of 2 shown with thick figures.

4.2.3 Sectional designation for R_z If it is required to designate R_z, in a certain section, numerical values corresponding to the upper limit (the larger value of the designated value) and the lower limit (the smaller value of the section shall be selected from Table 4 and be stated together.

Example 1. If the standard values for reference lengths of upper and lower limits are equal The sectional designation for the upper limit of 6.3 μmR_z, and lower limit of 1.60 μmR_z, shall be designated as (6.3 to 1.60) μmR_z. In this case, 0.8 mm shall be used for the reference length.

Example 2. If the standard values for reference lengths of upper and lower limits are different The sectional designation for the upper limit of 12.5 μmR_z, and lower limit of 1.60 μmR_z, shall be designated as (12.5 to 1.60) μmR_z. In this case, it means that the value of R_z, measured using a reference length of 2.5 mm is 12.5 μmR_z, or under, and that the value of R_z, measured using a reference length of 0.8 mm is 1.60 μmR_z, or over.

Remarks 1. In the case where reference lengths corresponding to the upper and lower limits are required to be equal, or when any reference length other than the standard value of Table 3 is to be used, the reference length shall be designated as Example 2., when the reference length corresponding to the upper and lower limits is selected as 2.5 mm, it shall be designated as (12.5 to 1.60) μmR_z, l 2.5 mm.

2. R_z, of the upper and lower limits mentioned here shall be an arithmetical mean value of R_z, at several places which have been sampled randomly from the designated surface, but shall not be the maximum value of individual R_z.

**5. Definition and designation of ten-point mean roughness (R_z)**

5.1 Definition of R_z

5.1.1 Determination of R_z R_z, shall be that only the reference length is sampled from the roughness curve in the direction of its mean line, the sum of the average value of absolute values of the heights of five highest profile peaks (Y_p) and the depths of five deepest profile valleys (Y_v) measured in the vertical magnification direction from the mean line of this sampled portion and this sum is expressed in micrometer (μm) (see Fig. 4).

$$R_z = \frac{|Y_{p1} + Y_{p2} + Y_{p3} + Y_{p4} + Y_{p5}| + |Y_{v1} + Y_{v2} + Y_{v3} + Y_{v4} + Y_{v5}|}{5}$$

where, $Y_{p1}, Y_{p2}, Y_{p3}, Y_{p4}, Y_{p5}$: altitudes of the heights of five highest profile peaks of the sampled portion corresponding to the reference length l

$Y_{v1}, Y_{v2}, Y_{v3}, Y_{v4}, Y_{v5}$: altitudes of the depths of five deepest profile valleys of the sampled portion corresponding to the reference length l

Fig. 4. Determination of R_z
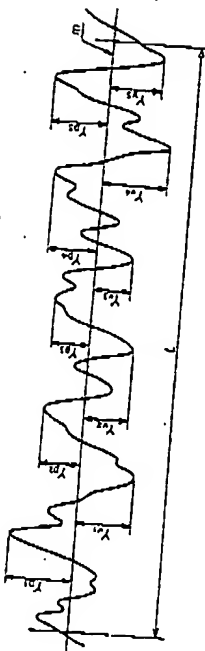
5.1.2 Reference length The reference length, in the determination of R_z, shall generally be chosen from the following six kinds:

0.08, 0.25, 0.8, 2.5, 8, 25 Unit: mm

5.1.3 Standard values of reference lengths The standard values of the reference lengths and the evaluation lengths corresponding to the range of R_z, in the determination of R_z, should conform to the division of Table 5 generally.

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Table 6. Preferred number series of R_z

Unit: μm

0.125	1.25	12.5	125	1250
0.160	1.60	16.0	160	1600
0.20	2.0	20	200	
0.25	2.5	25	250	
0.32	3.2	32	320	
0.40	4.0	40	400	
0.50	5.0	50	500	
0.63	6.3	63	630	
0.80	8.0	80	800	
1.00	10.0	100	1000	

(left column: 0.025, 0.032, 0.040, 0.050, 0.063, 0.080, 0.100)

Remarks: It is preferable to use the number series of common ratio of 2 shown in thick figures.

5.2.3　Sectional designation for R_z　When it is required to designate R_z in a certain section, numerical values corresponding to the upper limit (the larger designated values) and the lower limit (the smaller value of the designated values) of that section shall be selected from Table 6 and be stated together.

Example 1.　If the standard values for reference length of upper limit and lower limit are equal　The sectional designation for the upper limit 6.3 μmR_z, and lower limit 1.60 μmR_z, shall be designated as (6.3 to 1.60) μmR_z. In this case, 0.8 mm shall be used for the reference length.

Example 2.　If the standard values for reference length of upper limit and lower limit are different　The sectional designation for the upper limit 12.5 μmR_z, and the lower limit 1.60 μmR_z, shall be designated as (12.5 to 1.60) μmR_z. In this case, it means that the value of R_z, measured in the reference length of 2.5 mm is 12.5 μmR_z or under, and that the value of R_z, measured in the reference length of 0.8 mm is 1.60 μmR_z, or over.

Remarks 1.　If it is required to equalize the reference lengths corresponding to the upper and lower limits or if any reference length other than the standard value of Table 5 is used, the reference length corresponding to the upper and lower limits shall be stated together. In Example 2, if the reference length corresponding to the upper and lower limits is to be taken as 2.5 mm, it shall be designated as (12.5 to 1.60) μmR_z, l 2.5 mm.

2.　R_z of the upper and lower limits mentioned here shall be an arithmetical mean value of R_z on several places randomly sampled from the designated surface, and shall not be the maximum value of individual R_z.

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Table 5. Standard values of reference lengths and evaluation lengths in determining R_z

Range of R_z (μm)		Reference length l (mm)	Evaluation length l_n (mm)
Exceeding	Max.		
(0.025)	0.10	0.08	0.4
0.10	0.50	0.25	1.25
0.50	10.0	0.8	4
10.0	50.0	2.5	12.5
50.0	200.0	8	40

The value within ( ) is given for informative reference.

Remarks:　R_z shall be determined on designating the reference length at first. In the case where the indication and designation of the surface roughness are to be carried out, because it is inconvenient to designate this on all such occasions, the values given in Table 5 should be used generally.

5.2　Expression of R_z

5.2.1　Designation of R_z　　The designation of R_z shall be as follows:

Ten-point mean roughness _____ μm, Reference length _____ mm, Evaluation length _____ mm

or

_____ μmR_z, l _____ mm, l_n _____ mm

Remarks 1.　When the values of R_z, obtained by using the standard values of reference length shown in Table 5 are within the range shown in Table 5, the designation of reference length may be omitted.

2.　When using the evaluation lengths of five times the reference lengths, namely, the standard values of evaluation lengths shown in Table 5, the designation of evaluation length may be omitted.

5.2.2　Preferred number series of R_z　　In the designation of the surface roughness by R_z, the preferred number series of Table 6 should be used generally.

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6. Definition and designation of mean spacing of profile irregularities (Sm)

6.1 Definition of Sm

6.1.1 Determination of Sm   Sm shall be that the portion equal to the reference length is sampled from the roughness curve in the direction of its mean line, and within this sampled portion, the sum of the lengths of mean lines corresponding to one of the profile peaks and one profile valley adjacent to it (hereafter referred to as "spacing of profile irregularities") is obtained and the arithmetical mean value of many spacings of these irregularities is expressed in millimeter (mm) (see Fig. 5).

$$S_m = \frac{1}{n} \sum_{i=1}^{n} S_{mi}$$

where, S_{mi} : spacing of irregularities

n : number of spacings of irregularity lying within the reference length

Fig. 5. Determination of Sm
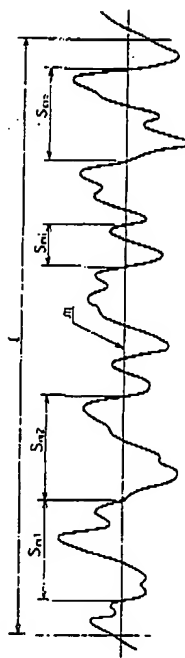
6.1.2 Reference length   The reference length, in the determination of S_n, shall generally be chosen from the following six kinds:

0.08, 0.25, 0.8, 2.5, 8, 25   Unit: mm

6.1.3 Standard values of reference length   The standard values of reference lengths and evaluation lengths corresponding to the range of S_m shall, in general, conform to the division of Table 7.

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Table 7. Standard values of reference length and evaluation length in determination of S_n

Range of S_n (mm)		Reference length l (mm)	Evaluation length l_n (mm)
Exceeding	Max.		
0.013	0.04	0.08	0.4
0.04	0.13	0.25	1.25
0.13	0.4	0.8	4
0.4	1.3	2.5	12.5
1.3	4.0	8	40

Remarks: S_n shall be determined upon designating the reference length. In the indication and designation of surface roughness, because it is inconvenient to designate on every occasion, the standard values of reference length and evaluation length given in Table 7 should be used generally.

6.2 Expression of S_n

6.2.1 Designation of S_n   The designation of S_n, shall be as follows:

Mean spacing of profile irregularities ____ mmS_m, l ____ mm, length ____ mm

Reference length ____ mm, length

Evaluation ____ mm

or

____ mmS_m, l ____ mm, l_n ____ mm

Remarks 1. If the value of S_n, determined by using the standard value of the reference length shown in Table 7 is within the range shown in Table 7, the designation of reference length may be omitted.

2. When using the evaluation length of five times the reference length, namely, the standard value of the evaluation length given in Table 7, the designation of evaluation length may be omitted.

6.2.2 Preferred number series of S_n   In the designation of surface roughness by S_m, the preferred number series in Table 8 should be used generally.

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## 7. Definition and designation of mean spacing of tops of local peak of profile (S)

7.1 Definition of S

7.1.1 Determination of S   S shall be that the portion equal to the reference length is sampled from the roughness curve in the direction of its mean line, and within this sampled portion, the length of mean line corresponding to the spacing between two adjacent tops of local peak of profile (hereafter referred to as "spacing of tops of local peak of profile") is obtained and the arithmetical mean value of spacings between these many tops of local peak of the profile is expressed in millimeter (mm) (see Fig. 6).

$$S = \frac{1}{n} \sum_{i=1}^{n} S_i$$

where, S_i : spacing of tops of local peak of profile

n : number of spacings between tops of local peak of profile within the reference length

Fig. 6. Determination of S
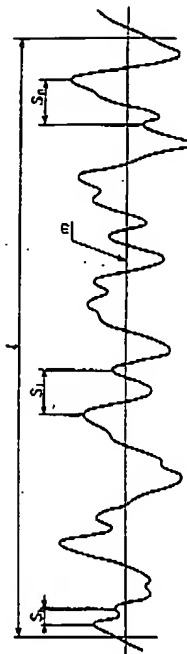
7.1.2 Reference length   The reference length, in the determination of S, shall be chosen from the following six kinds in general:

0.08,　0.25,　0.8,　2.5,　8,　25   Unit: mm

7.1.3 Standard values of reference length   The standard values of reference lengths and evaluation lengths corresponding to the range of S in the determination of S shall conform to the division given in Table 9.

Table 8. Preferred number series of S_m

Unit: mm

	0.0125	0.125	1.25	12.5
	0.0160	0.160	1.60	
	0.020	0.20	2.0	
0.002	0.025	0.25	2.5	
0.003	0.032	0.32	3.2	
0.004	0.040	0.40	4.0	
0.005	0.050	0.50	5.0	
0.006	0.063	0.63	6.3	
0.008	0.080	0.80	8.0	
0.010	0.100	1.00	10.0	

Remarks: It is preferable to use the number series of common ratio of 2 shown in thick figures.

6.2.3 Sectional designation for S_m When it is required to designate S_m in a certain section, the numerical values corresponding to the upper limit (the larger value of the designated values) and the lower limit (the smaller value of the designated values) of that section shall be selected from Table 8 and be described together.

Example 1.   If the standard values of reference length of upper limit and lower limit are equal   The sectional designation for the upper limit of 0.100 mmS_m and the lower limit of 0.050 mmS_m shall be indicated as (0.100 to 0.050) mmS_m. In this case, 0.25 mm shall be used for the reference length.

Example 2.   If the standard values of reference length of upper limit and lower limit are different   The sectional designation for the upper limit of 0.80 mmS_m and the lower limit of 0.20 mmS_m shall be indicated as (0.80 to 0.20) mmS_m. In this case, it means that the value of S_m measured in the reference length of 2.5 mm is 0.80 mmS_m or under, and that the value of S_m measured in the reference length of 0.8 mm is 0.20 mmS_m or over.

Remarks 1.   If it is required to equalize the reference lengths corresponding to the upper and lower limits or if other reference lengths than the standard values shown in Table 7 are used, the reference length shall be described together. In Example 2., if reference length corresponding to the upper and lower limits is taken as 2.5 mm, it shall be designated as (0.80 to 0.20) mmS_m, l 2.5 mm.

2. S_m of the upper and lower limits mentioned here shall be the arithmetical mean value of S_m at several places sampled at random from the designated surface and not be the maximum value of individual S_m.

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Table 9. Standard values of reference length and evaluation length in determination of S

Range of S (mm)		Reference length l (mm)	Evaluation length l_n (mm)
Exceeding	Max.		
0.013	0.04	0.08	0.4
0.04	0.13	0.25	1.25
0.13	0.4	0.8	4
0.4	1.3	2.5	12.5
1.3	4.0	8	40

Remarks: S shall be determined upon designating the reference length. In the indication and designation of surface roughness, because it is inconvenient to designate on every occasion, the standard values of reference length and evaluation length shown in Table 9 should be used generally.

7.2 Expression of S

7.2.1 Designation of S   The designation of S shall be as follows:

Mean spacing of tops of local peak of profile _____ mm, Reference length _____ mm, Evaluation length _____ mm

or

_____ mmS, l _____ mm, l_n _____ mm

Remarks 1. If the value of S determined by using the standard value of the reference length shown in Table 9, is in the range shown in Table 9, the designation of reference length may be omitted.

2. When using the evaluation length of five times the reference length, namely, the standard value of evaluation length shown in Table 9, the designation of evaluation length may be omitted.

7.2.2 Preferred number series of S   In the designation of surface roughness by S, the preferred number series in Table 10 should be used generally.

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Table 10. Preferred number series of S

Unit: mm

	0.0125	0.125	1.25	12.5
	0.0160	0.160	1.60	
0.002	0.020	0.20	2.0	
0.003	0.025	0.25	2.5	
0.004	0.032	0.32	3.2	
0.005	0.040	0.40	4.0	
0.006	0.050	0.50	5.0	
	0.063	0.63	6.3	
0.008	0.080	0.80	8.0	
0.010	0.100	1.00	10.0	

Remarks: It is preferable to use the number series of common ratio of 2 indicated by thick figures.

7.2.3 Sectional designation for S   When it is required to designate S in a certain section, the numerical values corresponding to the upper limit and the lower limit (the smaller value of the designated values) of that section shall be selected from Table 10 and be described together.

Example 1. If the standard values of reference length of upper limit and lower limit are equal   The sectional designation for the upper limit of 0.100 mmS and the lower limit of 0.050 mmS shall be indicated as (0.100 to 0.050) mmS. In this case, 0.25 mm shall be used for the reference length.

Example 2. If the standard values of reference length of upper limit and lower limit are different   The sectional designation for the upper limit of 0.80 mmS and the lower limit of 0.20 mmS shall be indicated as (0.80 to 0.201) mmS. In this case, it means that the value of S measured in the reference length of 2.5 mm is 0.80 mmS or under and that the value of S measured in the reference length of 0.8 mm is 0.20 mmS or over.

Remarks 1. If it is required to equalize the reference lengths corresponding to the upper and lower limits or if other reference lengths than the standard values shown in Table 9 are used, the reference length shall be described together. In Example 2, if the reference length corresponding to the upper and lower limits is taken as 2.5 mm, it shall be designated as (0.80 to 0.20) mmS, l 2.5 mm.

2. S of the upper and lower limits mentioned here shall be the arithmetical mean value of S at several places sampled at random from the designated surface and not be the maximum value of individual S.

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8. Definition and designation of profile bearing length ratio (t_p)

8.1 Definition of t_p

8.1.1 Determination of t_p t_p shall be that the portion equal to the reference length is sampled from the roughness curve in the direction of its mean line and the ratio of the sum of cut lengths obtained at the cutting levels parallel to the top of profile peak line (profile bearing length, η_p) to the reference length is expressed in percentage portion of roughness curve at the cutting levels parallel to the top of profile peak (see Fig. 7).

$$t_p = \frac{\eta_p}{l} \times 100$$

where, η_p : $b_1 + b_2 + \cdots + b_n$
        l : reference length

Fig. 7. Determination of t_p
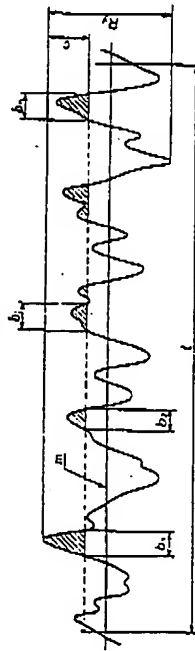
8.1.2 Reference length The reference length, in the determination of t_p, shall be selected from the following six kinds in general:

0.08, 0.25, 0.8, 2.5, 8, 25   Unit: mm

8.1.3 Cutting level The cutting level at the time of determining t_p shall be in accordance with any one of the following two methods:

(1) Express with the numerical value in micrometer (μm).

(2) Express its ratio to R_y with percentage (%). The preferred number series to be used in this case is shown below:

5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 75, 80, 90

Remarks: When expressing c with the percentage (%) in accordance with (2), it is necessary to obtain R_y in the first place from the roughness curve in the reference length.

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8.2 Expression of t_p

8.2.1 Designation of t_p The designation of t_p shall be as follows:

| Profile bearing | Cutting | Reference | Evaluation |
| length ratio ___ %, | level ___ μm, | length ___ mm, | length ___ mm |

or

___ % t_p, c ___ μm, l ___ mm, l_n ___ mm

Or

| Profile bearing | Cutting | Reference | Evaluation |
| length ratio ___ %, | level ___ %, | length ___ mm, | length ___ mm |

or

___ % t_p, c ___ %, l ___ mm, l_n ___ mm

Remarks: To the briefing form for designating the reference length and evaluation length, the case of R, applies (see Remarks 1. and 2. in 4.2.1).

8.2.2 Preferred number series of t_p When designating the surface roughness by t_p, the preferred number series in Table 11 shall be used in general.

Table 11. Preferred number series of t_p

t_p (%)	10	15	20	25	30	40	50	60	70	80	90

8.2.3 Sectional designation for t_p When it is required to designate t_p in a certain section, the numerical values corresponding to the upper limit (the larger value of the designated values) and the lower limit (the smaller value of the designated values) shall be selected from Table 11 and be described together.

Remarks: For the standard values of reference lengths for the upper limit and lower limit, the values specified in Table 3 at the time of determining R_y shall be used.

Example 1. If the reference length is equal to the standard value   In the case of (6.3 to 1.60) μmR, 0.8 mm shall be used as the reference length. The sectional designation for the upper limit of t_p of 60 % and the lower limit thereof of 40 % shall be (60 to 40) %t_p, c40%.

Example 2. If the reference length is unequal to the standard length   The upper limit and lower limit of t_p shall be described together and the following reference length shall be written additionally:

(60 to 40) %t_p, c40 %, l 2.5 mm

Remarks: t_p of the upper limit and lower limit mentioned here shall be the arithmetical mean value of t_p at several places sampled at random from the designated surface and not be the maximum value of individual t_p.

-B 0601-

Annex   Definition and designation of center line average roughness

1. **Scope**   This Annex specifies the definition and designation of the center line average roughness (R_{a75}).

Informative reference: The contents of this Annex which are not in conformance with the International standards will be abolished at an appropriate time.

2. **Definitions and symbols**.   For the main terms used in this Annex, the following definitions apply:

The symbols for them are shown in ( ), next to the respective terms.

(1) roughness curve for determining R_{a75} (75%)   Curve made by extracting the components of surface roughness shorter than a given wavelength on a profile curve by using the high-pass filter of the decay factor of -12 dB/oct [hereafter referred to as "roughness curve (75 %)"].

(2) cut-off value (75 %) of roughness curve (75 %) (λ_{c75})   The wavelength corresponding to the frequency with which the gain of high-pass filter becomes 75 % [hereafter referred to as "cut-off value (75 %)].

(3) mean line of roughness curve (75 %)   The straight line or the curve having the geometrical shape of the surface to be measured at the sampled portion of roughness curve (75 %) and the line set so as to make the sum of squares of deviation up to the roughness curve (75 %) minimum.

(4) center line of roughness curve (75 %)   The straight line or the curve on the both sides of which the area surrounded by the straight line or the curve parallel to the mean line of roughness curve (75 %) and the roughness curve (75 %) become equal (hereafter referred to as "center line").

3. **Definition and designation of center line average roughness (R_{a75})**

3.1 **Definition of R_{a75}**

3.1.1 **Determination of R_{a75}** R_{a75} is the value obtained by the following formula and expressed in micrometer (μm) under the condition that the portion of measuring length (L) is sampled from the roughness curve (75 %) in the direction of its center line, the center line of the sampled portion is considered as X-axis and the direction of the longitudinal axis as Y-axis, and the roughness curve (75 %) is represented by $y = f(x)$:

$$R_{a75} = \frac{1}{L} \int_0^L |f(x)| dx$$

where, L : measuring length

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3.1.2 λ_{c75} λ_{c75} shall be the following six kinds:

0.08, 0.25, 0.8, 2.5, 8, 25   Unit: mm

3.1.3 **Standard value of λ_{c75}**   The standard value of λ_{c75} shall, in general, be in accordance with the division shown in Annex Table 1.

Annex Table 1. Standard value of λ_{c75} in determining of R_{a75}

Range of R_{a75} (μm)		Cut-off value (75 %) λ_{c75} (mm)
Exceeding	Max.	
-	12.5	0.8
12.5	100	2.5

Remarks: R_{a75} shall be determined upon designating λ_{c75} first. When designating or instructing the surface roughness, the values given in Annex Table 1 are used in general, because it is inconvenient to designate them at every time.

3.1.4 **Measuring length**   The measuring length shall be the value not shorter than three times λ_{c75}.

3.2 **Expression of R_{a75}**

3.2.1 **Designation of R_{a75}**   The designation of R_{a75} shall be as follows:

Center line average roughness (75 %) _____ μm, value (75 %) _____ mm, length _____ mm

    [Cut-off value (75 %)]   [Measuring length]

or

_____ μmR_{a75}, λ_{c75} _____ mm, L _____ mm

Remarks 1. If the value of R_{a75} obtained by using the standard value of λ_{c75} shown in Annex Table 1 lies within the range of Annex Table 1, the designation of λ_{c75} may be omitted.

2. If the measuring length is three times λ_{c75} or longer, the designation of measuring length may be omitted.

3.2.2 **Preferred number series of R_{a75}**   When designating the surface roughness by R_{a75}, the preferred number series in Annex Table 2 should be used generally.

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JIS B 0405
(1991)

General tolerances—Part 1: Tolerances for linear and angular dimensions without individual tolerance indications

Foreward as the Japanese Industrial Standard

This Standard is the Japanese Industrial Standard drawn up without changing the technical contents and the form of copy of standard, translating the ISO 2768-1 (General tolerances—Part 1: Tolerances for linear and angular dimensions without individual tolerance indications) published on 1989 as the first edition.

Furthermore, "Informative References" underlined (dotted lines) in this Standard are the matters not included in the original International Standard.

Introduction

All features on component parts always have a size and a geometrical shape. For the deviation of size and for the deviations of the geometrical characteristics (form, orientation and location) the function of the part requires limitations which, when exceeded, impair this function.

The tolerancing on the drawing should be complete to ensure that the elements of size and geometry of all features are controlled, i.e. nothing shall be implied or left to judgement in the workshop or in the inspection department.

The use of general tolerances for size and geometry simplifies the task of ensuring that this prerequisite is met.

1. Scope

This Standard is intended to simplify drawing indications, and it specifies general tolerances for linear and angular dimensions without individual indications in four tolerance classes.

Remarks 1. The concepts behind the general tolerancing of linear and angular dimensions are described in Annex A.

This Standard applies to the dimensions of parts which have been produced by metal removal or parts which have been formed from steel metal.

2. These tolerances may be suitable for use with materials other than metal.

3. Similar standards exist or are planned. For example, see JIS B 0403 for castings.

Informative reference: JIS B 0403-1987 is the International Conforming Standard of ISO 8062: 1984 (Castings-System of dimensional tolerances).

This Standard only applies to the following dimensions without individual tolerance indications:

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Annex Table 2. Preferred number series of R_{a75}

Unit: μm

0.013	0.4	12.5
0.025	0.8	25
0.05	1.6	50
0.1	3.2	100
0.2	6.3	

3.2.3 Sectional designation for R_{a75}　　When it is required to designate R_{a75} in a certain section, the numerical values corresponding to the upper limit (the larger value of the designated values) and the lower limit (the smaller value of the designated values) shall be selected from Annex Table 2 and be described together.

Example 1. If the standard values of λ_{c75} at the upper limit and the lower limit are equal　　The sectional designation for the upper limit of 6.3 μmR_{a75} and the lower limit of 1.6 μmR_{a75} shall be (6.3 to 1.6) μmR_{a75}. In this case, the cut-off value (75 %) of 0.8 mm shall be used.

Example 2. If the standard values of λ_{c75} at the upper limit and the lower limit are different　　The sectional designation for the upper limit of 25 μmR_{a75} and the lower limit of 6.3 μmR_{a75}. In this case, it means that the value of R_{a75} measured with λ_{c75} 2.5 mm is not more than 25 μmR_{a75} and the value of R_{a75} measured with λ_{c75} 0.8 mm is not less than 6.3 μmR_{a75}.

Remarks 1 If it is required to equalize both λ_{c75} corresponding to the upper limit and the lower limit or if the values of λ_{c75} other than the standard values in Annex Table 1 are used, λ_{c75} shall be written together. In Example 2, if λ_{c75} corresponding to the upper limit and the lower limit is 2.5 mm, the designation shall be (25 to 6.3) μmR_{a75}, λ_{c75} 2.5 mm.

2. R_{a75} of the upper limit and lower limit mentioned here shall be the arithmetical mean value of several places sampled at random from the designated surface and not be the maximum value of individual R_{a75}.